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Inquiry-based Learning with a Digital Humanities Research Platform's Support to Facilitate Students' Historical Investigation Performance

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Abstract

A historical investigation is a kind of inquiry-based learning, aiming to guide students' reading and analyzing processes of historical text to enhance the historical thinking. For this reason, a Digital Humanities Research Platform for Mr. Lo Chia-Lun's Writings (DHRP-MLCLW) with Perspective Change and Chronological Division Tool (PCCDT) is used for assisting senior high school students in inquiry-based learning activities of history course. It is expected to help learners understand historical investigation issues from different perspectives and aspects as well as enhance learners' understanding and inquiry abilities of interpreting historical text and context. With a pre-experimental research design, a total of 13 Grade 10 students in a senior high school in Taipei City, Taiwan, were recruited as the research participants for DHRP-MLCLW with PCCDT supported history inquiry course to examine whether learners significantly promote inquiry-based learning performance and to investigate students' learning satisfaction. Furthermore, lag sequential analysis (LSA) is applied to explore the effective behavior transition mode of learners with high learning performance. Semi-structured interview is also utilized for understanding learners' perception and suggestions about using the DHRP-MLCLW with PCCDT for history inquiry course. The research results show that DHRP-MLCLW with PCCDT supported history inquiry course could effectively enhance learners' learning performance and led to highly positive learning satisfaction. Moreover, the LSA results reveal that compared with the learners with low learning performance, the behavioral patterns among those with high learning performance using the DHRP-MLCLW with PCCDT for inquiry-based historical investigation better reflect the spirit of inquiry-based learning.

Keywords: Inquiry-based Learning; Digital Humanities and Technology; Historical Investigation; Assessment of Learning Performance; Learning Behavior Analysis

1. Introduction

Inquiry-based learning is a primary and compelling teaching mode internationally (Alake-Tuenter et al., 2013). Bringing up questions is the core of inquiry-based learning, allowing learners to solve ill-structured problems, or collecting various information to enhance the comprehension of subjects and helping teachers play the roles of assisting in constructing knowledge. In the learning process, learners are guided by teachers to seek for information related to questions at hand, as well as find out problem solving methods through collecting and analyzing data. Learners are given more autonomy to raise the skill of self-

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learning (Blessinger & Carfora, 2014; YouthLearn, 2016) and further cultivate independent thinking and problem-solving abilities.

There are many different instructional designs in inquiry-based learning that could be integrated into courses of various subjects (Blessinger & Carfora, 2014), but so far most of the attempts have been focused on its application to mathematics and science, scientific education, and information literacy (Chen et al., 2017; Dobber et al., 2017). The inquiry-based learning design was also applied to language (Ajit et al., 2016) and reading (Chu et al., 2011; Ermawati et al., 2017) in past years. The historical investigation is a kind of inquiry-based learning that requires students to develop and apply the research skills of a historian to explore a historical topic of students' choice. Students will be required to search, select, evaluate, and induce information, and then propose relevant evidences to draw conclusions. However, to the best of our knowledge, there is little research relating to historical investigation based on inquiry-based learning.

Digital humanities (DH) is an emerging field applying information technology to explore a huge number of digital data for humanities research (McCarty, 2008). The development of digital humanities tools or platforms aimed to help humanities scholars organize and analyze textual data for probing text context (Gibbs & Owens, 2012) as well as phenomena in texts worth of further studies (Schreibman et al., 2008). In other words, research on digital humanities is the process applying digital humanities tools or platforms for topic inquiry. It is expected that performing inquiry-based learning with digital humanities tools' or platforms' support is able to enhance the innovativeness of the pedagogy of humanities. Thus, this study aims to develop a digital humanities platform assisted history inquiry-based learning approach, and to examine the research questions about whether the learning approach proposed could effectively enhance students' learning performance and learning satisfaction, and explore the behavioral patterns of those who were able to use the digital humanities platform effectively to perform inquiry-based learning in a history course.

2. Literature Review

2.1 Digital humanities tools/platforms to facilitate humanities education

Digital humanities, originated from humanities computing, refer to utilizing computer's computing power for assisting humanities scholars in analyzing text or image contents to reduce the costs of data acquisition and exploration (Hockey, 2004). Berry (2012) defined digital humanities as using information technology for humanities scholars' research to discover previously unknown phenomena or issues, and studies which could not be proceeded by paper-based reading in the past.

Text analysis in digital humanities research generally could be divided into close reading and distant reading. Close reading refers to users' self-explanation of textual contents after carefully reading texts (Fisher & Frey, 2014), allowing users to more thoroughly explain text paragraphs by using such as digital text reading and text annotation (Chen et al., 2019). For example, Chinese Ancient Books Digital Humanities Research Platform (Chen & Chang, 2019) provides digital reading interface and

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automatic text annotation system for users' mutual reference. Distant reading, on the other hand, mostly involves content summary or abstract extraction from texts through digital humanities tools, for re-explanation (Jänicke et al., 2015). In other words, users, through distant reading, could acquire high-level information, which could not be discovered through manual reading texts (Fuller, 2020). Since the concept of digital humanities was proposed, the development of distant reading tools for analyzing texts through digital humanities tools has become more and more popular, such as social network analysis (Chen et al., 2021), geographic information (Bol, 2020; Chen et al., 2020), and information visualization (Tu et al., 2020), to support humanities scholars in analyzing vocabulary distribution, text semantics, text relations and context, and time-space correspondence hidden in digital texts to extract useful messages and clues as well as find out new knowledge. A good digital humanities tool or platform should provide both close reading and distant reading functions for mutual reference (Jänicke et al., 2017; Moretti et al., 2016).

Along with the development in digital humanities field and the promotion of digital humanities education in past years, research on humanities education with the support of digital humanities tool has gain momentum. For example, Zhou (2020) attempted to apply the Data-Platform of Chronological Map of Literature of Tang-Song Dynasties to the teaching of Chinese classical poems. Sit and Guo (2019) attempted to teach Chinese for students through digital technology support and flipped learning in Australia and proposed that the teaching mode with the support of digital humanities tool should present dynamic activities, enhance interaction, and enable flipped learning, which materializes the spirit of constantly interacting and conversing with digital humanities tools. Different from teacher's instruction, students cannot directly obtain solutions related to target problems when using digital humanities tools to support learning activities, but digital humanities tools emphasize on providing distant reading vision and inspiration for deepening students' inquiry (Tracy & Hoiem, 2017). Indeed, the history inquiry course supported with digital humanities tool has the potentials to be developed as a new mode of innovative humanities education.

2.2 History instruction supported with inquiry-based learning

Justice et al. (2007) indicated that inquiry-based learning is a series of student-centered teaching practice to cultivate students with the abilities of independent thinking and solving ill-structured problems. Spronken-Smith et al. (2008) claimed inquiry-based learning as the learning mode of seeking for new knowledge and comprehension, with student firmly placed as the center, teachers as helpers, and learning process being guided by problems. A complete inquiry-based learning mode is composed of several learning stages, including identifying and posing questions, designing and conducting investigations, analyzing data and evidence, using models and explanations, and communicating findings (Pedaste et al., 2012). Karplus and Their (1967) first proposed learning cycle with 3 stages of exploration, invention, and discovery for inquiry-based learning. With several times of modification, Bybee and Landes (1990) proposed

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5E learning cycle model for inquiry-based learning, including engagement, exploration, explanation, elaboration, and evaluation. Such a teaching model stressed on active knowledge construction and, meanwhile, could be the practice of learning inquiry ability (Duran & Duran, 2004).

Regarding the application of inquiry-based learning to history instruction, Reisman (2012) indicated that inquiry-based learning could benefit learners in developing history reasoning ability. Voet and Wever (2016) mentioned that inquiry-based learning, in history, provides learners with opportunities for investigating and exploring historical concepts or events and can cultivate learners' historical thinking. Wineburg et al. (2012) also emphasized that, in addition to "sourcing," "contextualization," and "corroboration" in history inspiration, learners should be guided to read historical materials with critical thinking and propose deep problems with history evidence. Nonetheless, there are many problems affecting the promotion of inquiry-based learning in current teaching practice, such as the lack of definite method to guide inquiry-based learning, lack of problem finding process, short of overall curriculum design, and inadequate data analysis and application. Levy et al. (2013) found that the obstacles faced by teachers to design inquiry-based learning include how to find suitable teaching resources and how to plan inquiry-based learning to match learners' knowledge level. Voet and Wever (2016) also indicated that many history teachers were lack of teaching experience and knowledge on integrating inquiry-based learning into history course. With the inquiry concept of 5E learning cycle (Bybee & Landes, 1990) and dividing the inquiry-based learning process into three inquiry stages of "engagement," "exploration," and "explanation," the digital humanities platform supported inquiry-based learning mode is developed for a historical investigation course in this study, with an aim to broaden the horizon of humanities education.

3. Research Methodology

3.1 Research participants

A total of 13 Grade 10 students from an experimental class that was composed of the students with excellent talent and aptitude on humanities and social science in a private senior high school in Taipei City, Taiwan, were recruited as the research participants, among them 6 are females. The main reason is that the senior high school has paid much attention on developing innovative humanities and social science education, particularly in "inquiry and practice" of social science subjects. During the instruction experiment, the school provided each of the students with a laptop for the inquiry-based learning activity in a classroom.

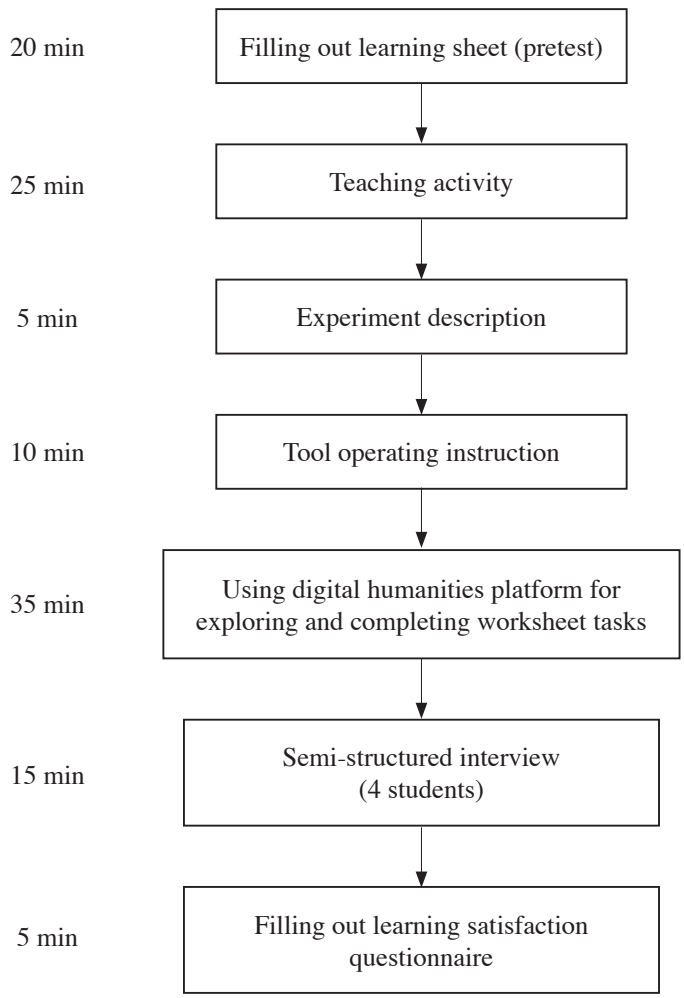
3.2 Experiment design

3.2.1 The design of experimental procedures

With a pre-experimental research design, the learning sheets of pretest and posttest were used as the assessment tool of learning performance; students' behavior process data were also recorded in the experimental process and analyzed after the experiment to discuss the effective behavioral model of students with high learning performance using Digital Humanities Research Platform for Mr. Lo Chia-Lun's Writings (DHRP-MLCLW) for history inquiry-based learning. The experimental procedures are shown in Figure 1. Before the

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Figure 1. The Experimental Procedures of This Study



instruction experiment, the students took part in the pretest of learning sheet for 20 minutes. The instruction experiment, where each student was equipped a laptop, was preceded in a classroom. In the instruction experiment, the history teacher first performed teaching activity, aiming to guide students to learn about Mr. Lo Chia-Lun and the historic knowledge under specific periods to induce students' learning interests; this part lasted for 25 minutes. The used teaching materials were several slides made by the history teacher, the themes are the brief biography and main experienced events of Mr. Lo Chia-Lun, and the delivery method of teaching activity is oral presentation by using slides. After the teaching activity, the researcher explained the experimental objectives and processes as well as the functions and operation of DHRP-MLCLW,

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for 15 minutes. The experimental objectives of the instruction experiment are to examine whether the DHRP-MLCLW with Perspective Change and Chronological Division Tool (PCCDT) is a useful tool in assisting inquiry-based learning activities of history course and can be developed as an innovative teaching mode for history courses. The students then used DHRP-MLCLW for the history subject exploration and completed worksheet tasks for 35 minutes. At the same time, the learning process data from the students were recorded through the xAPI technology for effectively behavioral mode analysis. After the experimental course, the researcher randomly selected 4 students for performing a 15-minute semi-structured interview and filling in the learning satisfaction questionnaire for a 5-minute to evaluate the students' satisfaction with the curriculum. The entire experiment was preceded for about 115 minutes.

3.2.2 The design of history inquiry-based learning course

The history inquiry course in this study was preceded the curriculum design based on the first 3 stages of 5E learning cycle, allowing students to learn the political change in early Republic of China, the historic knowledge of intellectuals who promoted New Culture Movement and May Fourth Movement, and asking students complete the learning tasks with DHRP-MLCLW support. The learning performance was evaluated according to the number of meaningful vocabularies, text content excerpts, and abstract essay of inquiry results in students' records. The evaluation criteria of learning performance were collaboratively made by the researcher and another history teacher participating in the experiment. The Cronbach's Alpha of the scorer reliability of the researcher and the history teacher was .95. The course content is based on the content of history of Republic of China in Book 2 in 2019 curriculum guidelines for history, including "Turmoil in early Republic of China," "New Culture Movement," and "May Fourth Movement"; and, the learning process, according to 5E learning cycle, was divided into 3 stages of engagement, exploration, and explanation. Engagement aims to induce students' learning interests in the course content; the teacher leaded the students, with guidance and Q&A, to learn about historical facts of "Politics in early Republic of China," "Social Changes," and "May Fourth Movement" in order to understand the contemporary history background. Finally, three questions were used for reinforcing students' knowledge about the subject. Exploration refers to students using digital humanities tools for exploration. After the engagement stage, students could link the past with the historic knowledge learned in the learning activity and use DHRP-MLCLW for exploring relevant texts and recording the keywords used and content excerpt summarized in the learning sheet. The keyword search used to explore relevant texts for assisting students to summarize content excerpt can be seen as parts of the results of inquiry-based learning according to the inquiry concept of 5E learning cycle (Bybee & Landes, 1990). Explanation allows students to explain the content explored with DHRP-MLCLW support at the exploration stage as well as the inspiration. After completing keyword and content excerpt in the learning sheet, students were requested to complete the abstract essay after organizing the content so that they understood the course

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more clearly and the comprehension of the inquired contents.

3.3 Research tool

3.3.1 Digital Humanities Research Platform for Mr. Lo Chia-Lun's Writings (DHRP-MLCLW)

DHRP-MLCLW, which supports humanities scholars' research on text analysis through distant reading and close reading, was developed as the history inquiry-based learning platform in this study. The platform contains the functions of user-friendly text reading interface, automatic text annotation with linked data, metadata search, full-text search, post classification of keyword search result, double keyword search, and visualized keyword's frequency distribution to enhance the efficiency of humanities scholars interpreting and analyzing text contents. The platform also develops the PCCDT based on conceptual history and information technology, expecting to help humanities scholars discuss the change of concepts in temporal texts along with time and assist in dividing texts into proper periods for observation to probe the concept or perspectives changes in Mr. Lo Chia-Lun's Writings. Figure 2 shows the user interface of DHRP-MLCLW. Currently, DHRP-MLCLW with PCCDT can be freely accessed through the Internet by the URL (http://lcl.ccstw.nccu.edu.tw). Users could start their historical investigation from "writing browse," "key-in a keyword for search," or "key-in two keywords for comparing their frequency distribution with time" to search the required texts.

Such a platform could visualize keyword search results with word frequency distribution and visualize word frequency distribution according to the classification of year (Figure 3), genre (Figure 4), and title (Figure 5), allowing users to view the text distribution of two keywords, according to different classification models. Users could, to some degree, understand the conceptual

Figure 2. The User Interface of DHRP-MLCLW



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Figure 3. The Year Distribution of Search Result for the Double Keywords "May Fourth Movement" and "Communist Party"

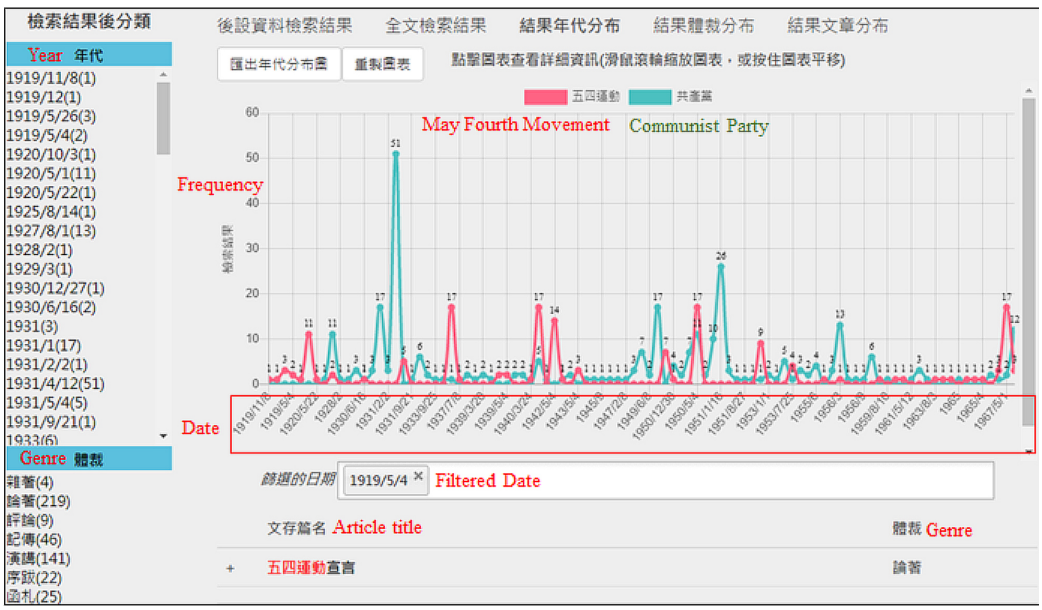
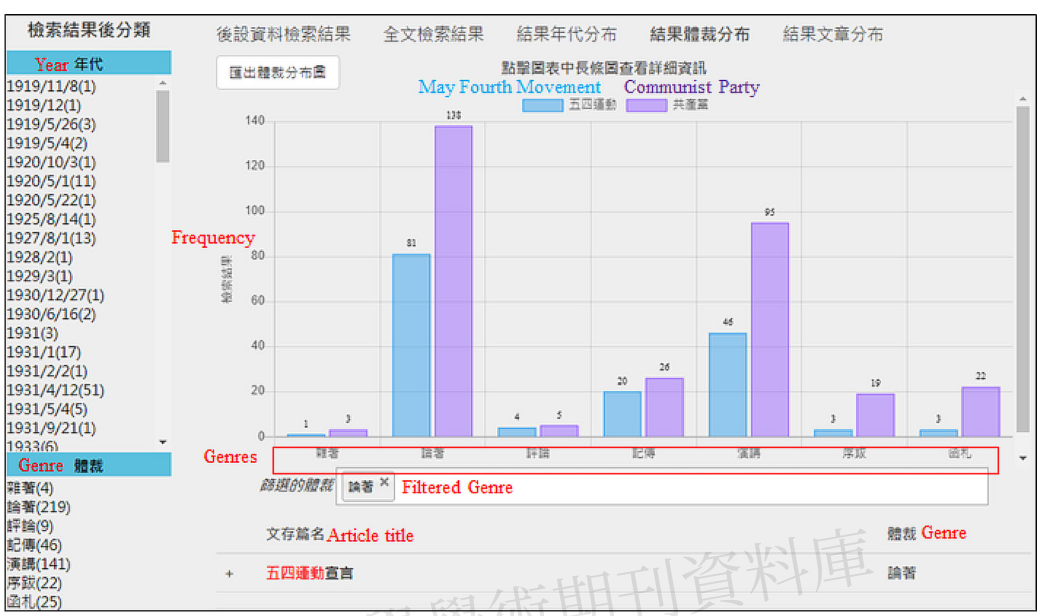
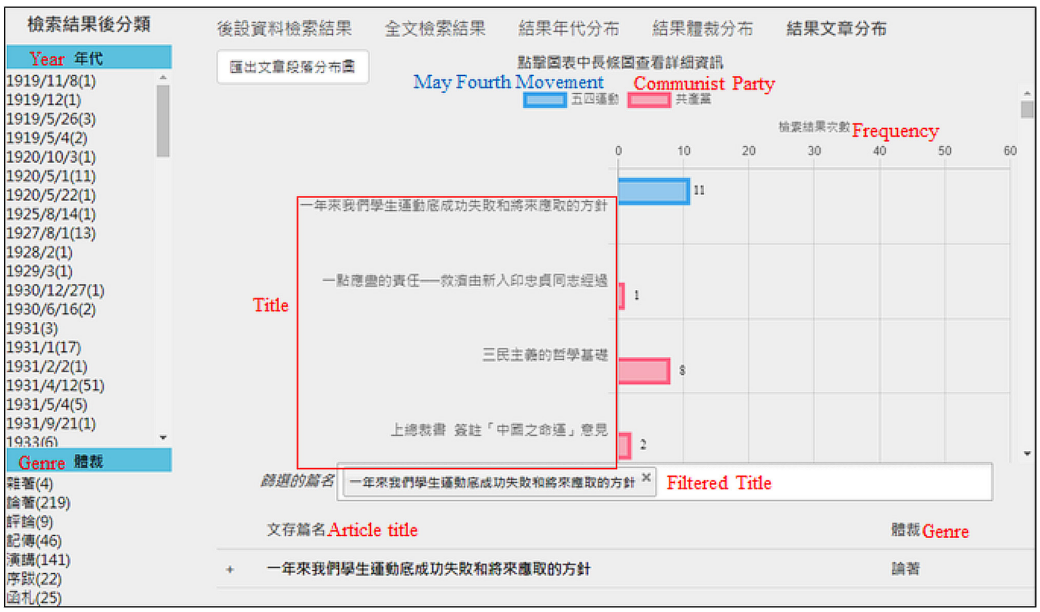


Figure 4. The Genre Distribution of Search Result for Double Keywords "May Fourth Movement" and "Communist Party"



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Figure 5. The Title Distribution of Search Result for Double Keyword "May Fourth Movement" and "Communist Party"



relationship between two keywords through the diagram. Moreover, a text under a desired year, genre, and title could be shown on the reading interface by clicking on the corresponding graph that represents the text for close reading.

Figure 6 shows the reading interface of a text. Users could browse the scanned file of the text in Mr. Lo Chia-Lun's Writings and the full text. The tools provided by the reading interface, from the left to the right, contain back to automatic annotation, article list (Figure 7), article information (Figure 8), cited article, browse mode, font size, and picture size.

Regarding the automatic annotation function, the platform, after a user clicks on automatic annotation tool, would automatically perform named entity recognition (NER) of the text and change the annotated fonts into several different colors. There are four type entities marked for the automatic annotation function including persons (red), organizations (green), places (blue), dates (brown) (Figure 9). When a user moves the mouse on the colored word, the word segmentation will be highlighted in red; after clicking on the word entity, the system would extract information, from authorized external web sites, such as CBDB (China Biographical Database), Moedict, and Wikipedia, to supplement the information about the word entity (Figure 10) so as to enhance user's understanding of the vocabulary and benefit user's text exploration.

The major concept of PCCDT is to precede chronological division and view perspective changes in various periods in Mr. Lo Chia-Lun's Writings. It allows users, through Mr. Lo Chia-Lun's aspects, to understand the social and political

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Figure 6. The Reading Interface of a Text



Figure 7. Article Lists

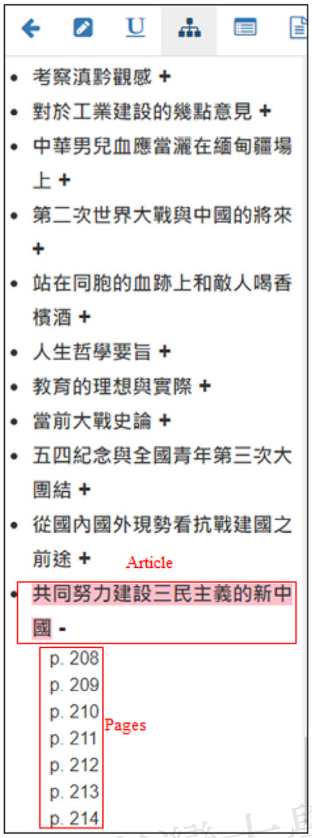


Figure 8. Article Information



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Figure 9. Four Type Entities of the Automatic Annotation Function

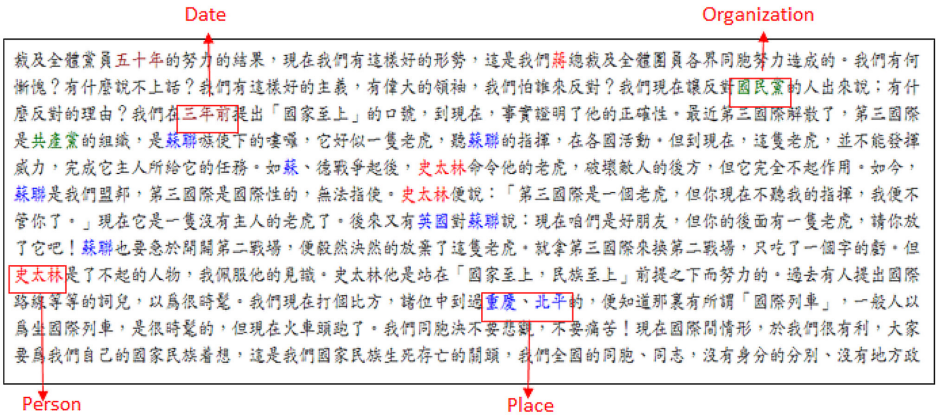
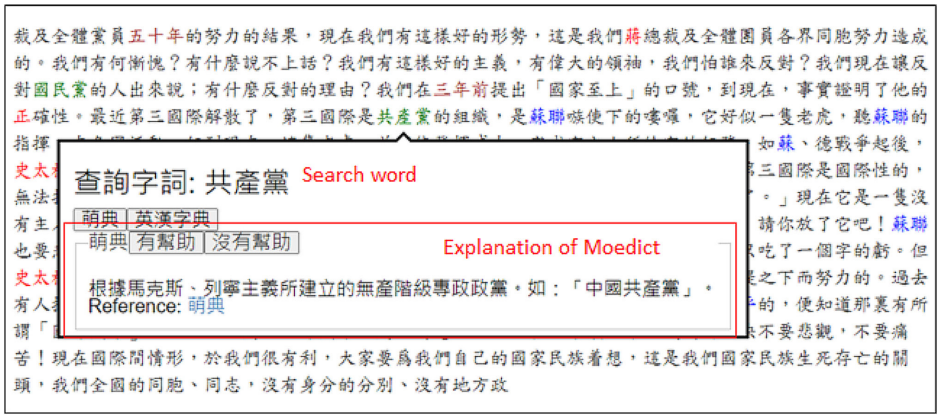


Figure 10. Supplementary Information of the Annotated Word from External Sources



concept changes in 1918-1968 to effectively help learners interpret Mr. Lo Chia-Lun's Writings and extract useful clues and information. The perspective change mining function is the major function of text interpretation of PCCDT. Users could execute the function after keying in keywords and setting chronological division (Figure 11).

PCCDT would perform Word2Vec vector analysis of text acquired from users keying in keywords at the "text division" stage, sequentially calculate keywords with similar semantics in various periods, extract top 10 related vocabularies that are mostly similar to searched keywords, and display with visualized graphic interface, as perspective network diagram (Figure 12).

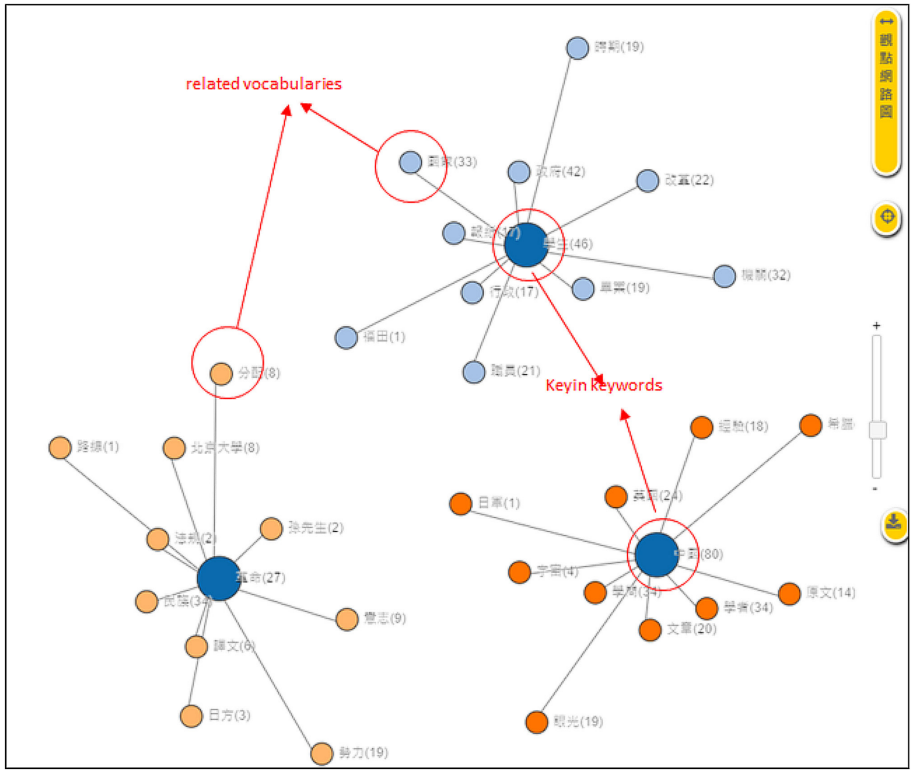
When clicking on the node related to a keyword in Figure 12, the related information about the keyword would be displayed, including the genre, year, title, and source of the keyword in the text (Figure 13). This page also presents the searched

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Figure 11. User Interface of Perspective Change Mining



Figure 12. The Perspective Network Diagram After Keying in Keywords



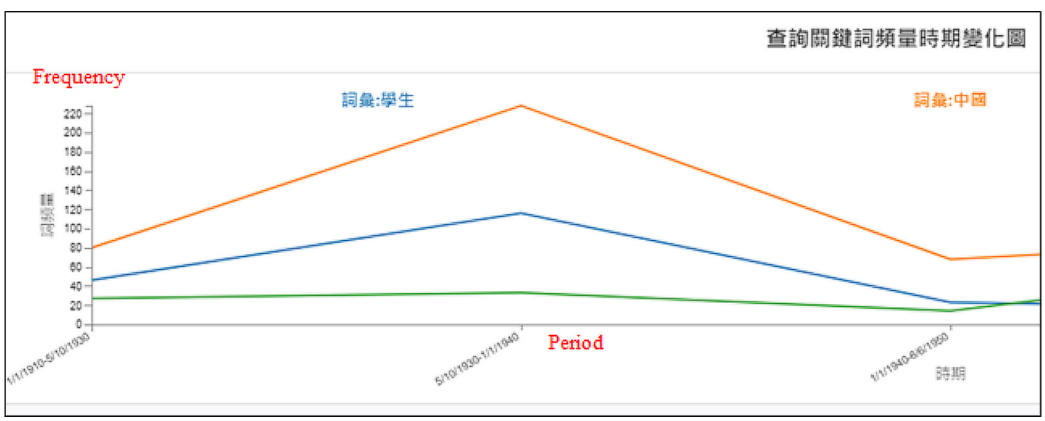
keyword, and the change of word frequency in various periods is shown in Figure 14. The detailed information of corresponding text could be searched by clicking on "source" of different texts (Figure 15). Users could also return to "modify keyword and year" after observing the result and re-select keywords for search, as well as precede "year segmentation" to correct the period segmentation point.

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Figure 13. The User Interface of Related Keyword Data Display



Figure 14. Time Change of Searched Keyword Frequency



3.3.2 Learning satisfaction questionnaire

The learning satisfaction questionnaire in this study was revised from the learning satisfaction questionnaire proposed by Chu et al. (2010). It is expected to understand learners' learning perception, learning satisfaction with the learning model and course content, and the future intention in the learning process for the reference of research result analysis.

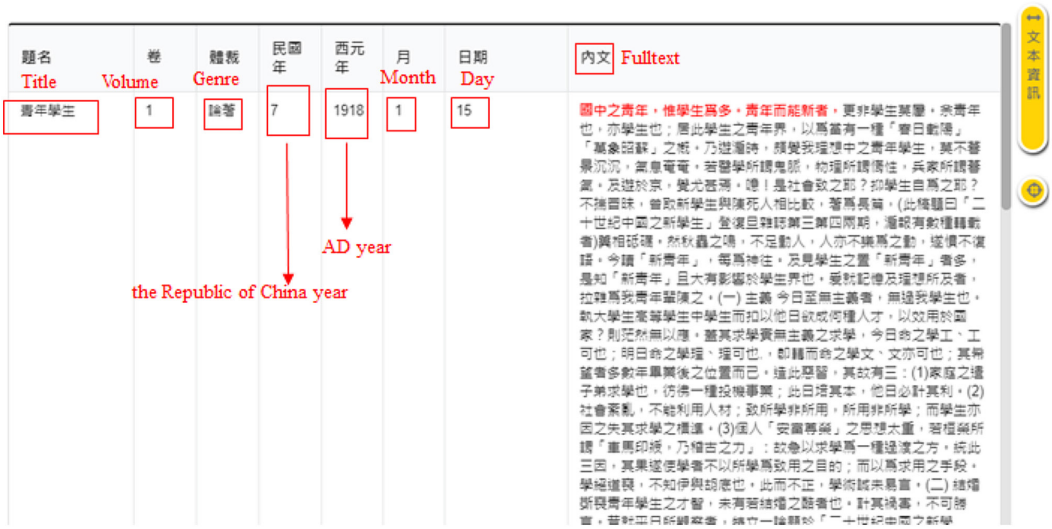
4. Experimental Results

4.1 Learning performance analysis of pretest/posttest scores

Since the number of research participants is small (n = 13) in this study, learning performance was analyzed with Wilcoxon signed-ranks test in nonparametric statistics method to test whether students notably enhance the learning performance of historical investigation before/

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Figure 15. The User Interface of Text Search



after performing inquiry-based learning with the support of digital humanities research platform. The Wilcoxon signed-ranks test results are shown in Table 1. The analytical results revealed that students, after using the digital humanities research platform, significantly enhance the learning performance (Z = -3.20, p = .001), showing that the learning model with DHRP-MLCLW supported history inquiry course could actually enhance senior high school students' learning performance.

4.2 Analysis of learning satisfaction

Table 2 shows the descriptive statistics of students' learning satisfaction, indicating that the mean of learning satisfaction is 4.10, higher than the median of the 6-point scale, revealing that students participating in the inquiry-based learning model present positive learning satisfaction towards the DHRP-MLCLW supported history inquiry-based learning course.

4.3 User behavior analysis

4.3.1 Behavior coding and explanation

Google analysis was embedded with a JavaScript code to record the platform's operation behaviors of each student. The platform's operation behaviors of each student were encoded as a series of behavior sequence samples with time stamp, according to the corresponding clicking behavior of each student defined in Table 3, such as encoding keyword search as A1, period switch as A4, for lag sequential analysis. The English letter A in the front of behavior number stands for the operation behaviors of PCCDT, and letter B represents the operation behaviors of DHRP-MLCLW. In summary, some platform's functions can support students to perform inquiry-based learning, particularly in the stages of exploration and explanation. For example, the platform's functions including the keyword search (A1), chronological division support (A6), external search (A8), operate perspective network diagram

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Table 1. Wilcoxon Signed-ranks Test Result of Students' Learning Performance

	Number of students (n = 13)		Z	p
	M	SD		
Pretest	1.62	1.45	-3.20	.001
Posttest	11.31	2.56		

Table 2. Descriptive Statistics of Students' Learning Satisfaction

Item	Number of students (n = 13)	
	M	SD
Learning satisfaction	4.10	1.06

Table 3. Behavior Coding and Explanation of Research Subjects' Use Behavior of PCCDT and DHRP-MLCLW

Encoding	Operation behavior	Explanation
A1	Keyword search	Key in one or more keywords for search. The function could draw the perspective network diagram.
A2	Period interval	Segment the entire period into several intervals, according to the set of period interval points. The marks "+" and "–" allow a user to add or delete period interval points.
A3	Digital humanities research platform connection	Click for opening the DHRP-MLCLW page.
A4	Period switch	Switch to view the result distribution in various periods.
A5	Change keyword and year	Click for returning the keyword search page.
A6	Chronological division support	Support the chronological division of keywords in the perspective network diagram.
A7	Digital humanities research platform search	Key in keywords to use the search function of DHRP-MLCLW.
A8	External search	Use the search function of external web sites, including CBDB, Moedict, and Wiki.
A9	Operate perspective network diagram	Operate perspective network diagram to view the information of article title, year, genre, and writings of the keyword source.
A10	Back to perspective network diagram	Return the perspective network diagram page.
A11	View keyword	Click for viewing the information of genre, year, title, and source of keyword in the perspective network diagram.
A12	Click on keyword to view text information	Click on the columns of genre, year, title, and source in the keyword page for viewing related text information.

(continued)

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Table 3. Behavior Coding and Explanation of Research Subjects' Use Behavior of PCCDT and DHRP-MLCLW (continued)

Encoding	Operation behavior	Explanation
A13	Back to keyword page	Return the keyword page.
A14	Keyword frequency period change	Present the word frequency amount of keyword in different periods, with a diagram.
A15	Back to text information page	Return the text information page. The information of title, volume, genre, year of Republic of China, AD year, month, date, and text content corresponding to the article in the keyword page is displayed.
A16	Notebook	Include the functions of preview, content copy, add, revise, and copy words.
A17	Back to notebook page	Return the notebook page.
B1	Back to homepage	Return the digital humanities research platform page.
B2	Writing browse	View all writing data recorded on the platform.
B3	Keyword search & double-word search	Simultaneously use the double-keyword cross-search function.
B4	Connection with perspective change tool	Click for opening the PCCDT page.
B5	Search of perspective change tool	Key in keywords and inquired period to directly search PCCDT.
B6	Post-classification of year	Keyword search result with "year."
B7	Post-classification of genre	Keyword search result with "genre."
B8	Metadata search	Sequence of metadata search result with writing title.
B9	Full-text search	Sequence of full-text search result with writing title.
B10	Result distribution of year	Present the search result of article year with scanned text.
B11	Result distribution of genre	Present the search result of article genre with scanned text.
B12	Result distribution of article	Present the search result of article title with scanned text.
B13	Click on article	Select to view article information with corresponding title.
B14	Reading interface	Several functions could be used for supporting reading the scanned text of selected article in the interface.
B15	Complete article information	Display information in the metadata columns of author, date, genre, and title.
B16	Automatic annotation	Precede word segmentation of words in the article and then annotate translation.
B17	Keyword annotation	Annotate keywords in the article.
B18	Article list	List other article titles with the same source of the article and the page connection.
B19	Article information	Display information in the metadata columns of author, date, genre, and title.
B20	Browse mode	Adjust word + picture or simple word model according to needs.
B21	Font size	Adjust the size of word on the right.
B22	Picture size	Adjust the size of picture of scanned text on the left.
B23	Click on article in writing browse	Click for the article displayed after clicking on the "writing browse" function.

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(A9), keyword search & double-word search (B3) can support the inquiry-based learning of the exploration stage, while the platform's functions including the post-classification of year (B6), result distribution of year (B10), automatic annotation (B16) can support the inquiry-based learning of the explanation stage.

4.3.2 Lag sequential analysis of behavior process

In this study, the difference between the pre- and post-test scores of historical investigation sheet was used as the basis for grouping learners into high and low learning performance groups in order to find out the effective learning behaviors of high learning performance group. Students whose difference between the pre- and post-test scores of historical investigation is higher than or equal to the average score of the class were considered as the high learning performance group, while the other students were considered as the low learning performance group. It is worth mentioning that these students enrolled from a private high school had had excellent talent and aptitude on social science and humanities. The low learning performance group means having relatively lower learning performance than the high learning performance group rather than poor learning performance. The behavior process statistical data of learners with different learning performance are drawn the behavior transition diagram with lag sequential analysis. Lag sequential analysis is a method for investigating how chains of behaviors and events are linked over time (Marono et al. 2018). The behavior transition diagrams of learners with high and low learning performance are shown in Figure 16 and Figure 17, respectively. Nodes in the behavior transition diagram represent learners' tool operation behavior, arrows denote the transition direction between behaviors, and the *Z* score of the behavior transition is higher than 1.96 reveals that the behavior transition achieves the significant state.

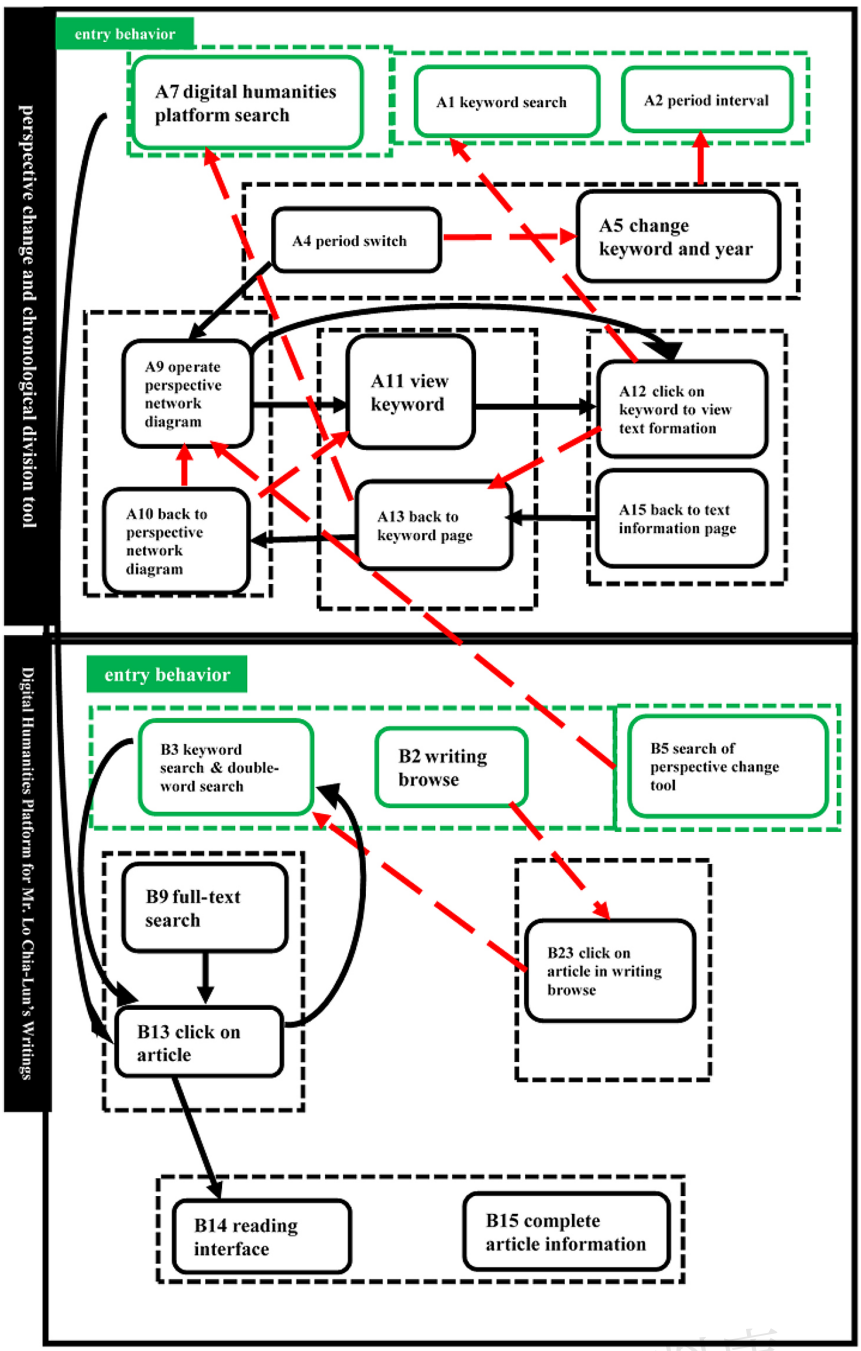
4.3.3 Comparison of learners with different learning performance on behavior transition in period switch

In lag sequential analysis, a *Z* score above 1.96 indicates that the sequence presents a remarkable coding transition and the learners with a significant behavioral transition in the platform's operation could be observed, and a high *Z* score indicates a more significant behavioral transition compared to a low *Z* score. By comparing the behavior transition of learners with different learning performance using the "period switch (A4)" function of the PCCDT (Table 4), learners with high/low learning performance showed a significant behavior transition in "keyword search (A1)" to "period switch (A4)" ($Z = 8.585$ for high, $Z = 5.468$ for low) and "period switch (A4)" to "operate perspective network diagram (A9)" ($Z = 3.522$ for high, $Z = 7.524$ for low); learners with high learning performance showed a significant behavior transition in "period switch (A4)" to "change keyword and year (A5)" ($Z = 3.834$), but learners with low learning performance do not reveal a significant transition in this kind of operation behavior.

Such a result reveals that learners with high learning performance would further think about the perspective network diagram after the period switch to ensure the desired results for exploring relevant information. Learners with low learning performance, on the other hand, would directly operate perspective network diagram after the

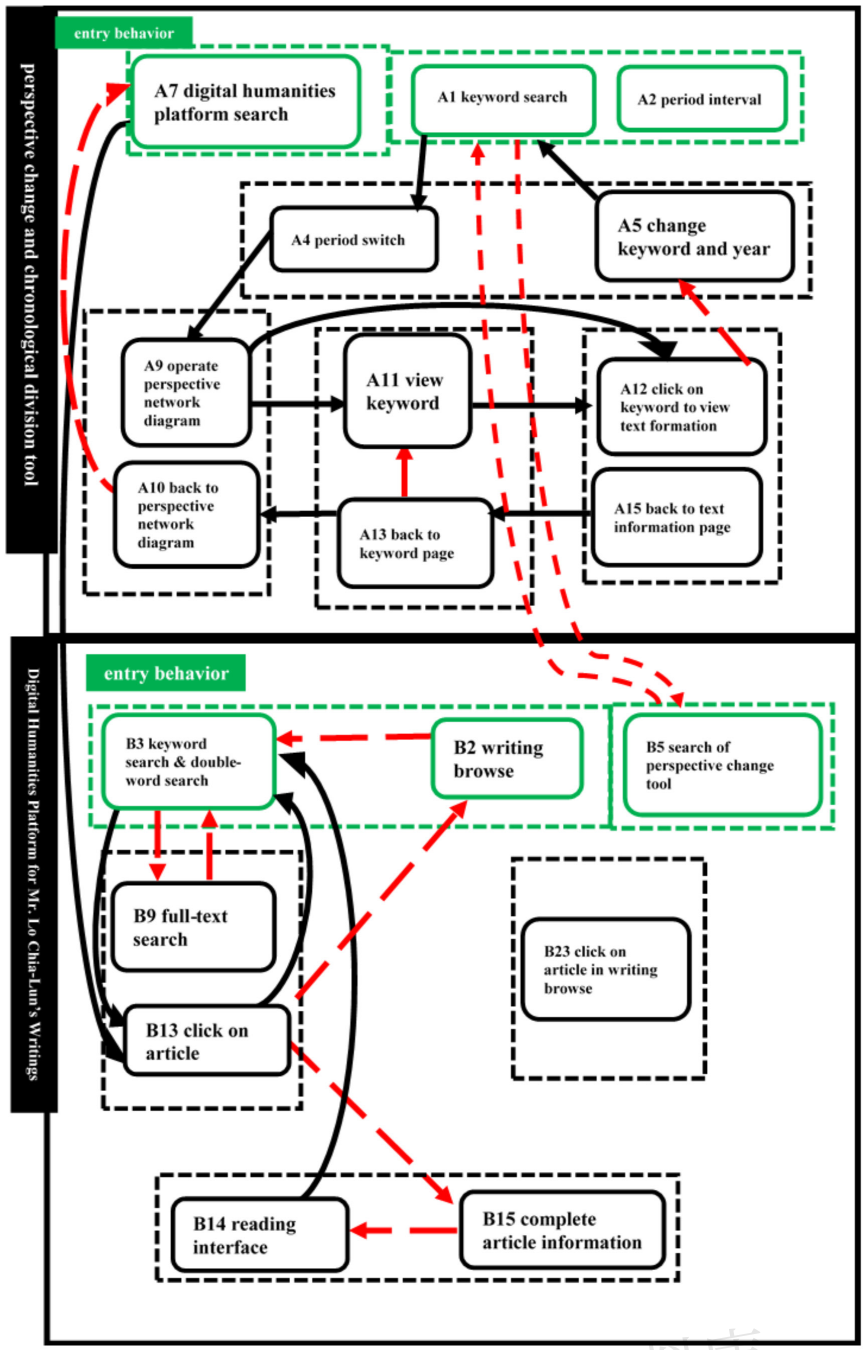
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Figure 16. Behavior Transition Diagram of Learners with High Learning Performance



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Figure 17. Behavior Transition Diagram of Learners with Low Learning Performance



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Table 4. Learners with Different Learning Performance—Behavior Model Difference in Period Switch

Perspective Change and Chronological Division Tool (PCCDT)		
	High learning performance (n = 6)	Low learning performance (n = 7)
keyword search (A1) → period switch (A4)	8.585	5.468
period switch (A4) → operate perspective network diagram (A9)	3.522	7.524
period switch (A4) → change keyword and year (A5)	**3.834**	

period switch and present lower probability to change the search result before operating perspective network diagram. Comparatively, learners with high learning performance showed the behavioral model of setting a goal and using tools for repeated exploration till the desired inquired data being searched. Such a behavioral model better conforms to the spirit of inquiry-based learning.

4.3.4 Comparison of learners with different learning performance on behavior transition in exploring related text data

By observing the behavior transition of learners with different learning performance using the "click on keyword to view text information (A12)" function of PCCDT (Table 5), learners with high learning performance showed a significant behavior transition in "click on keyword to view text information (A12)" to "search of perspective change tool (B5)" (Z = 2.464), "click on keyword to view text information (A12)" to "back to keyword page (A13)" (Z = 3.820), and "click on keyword to view text information (A12)" to "keyword search (A1)" (Z = 2.945), while learners with low learning performance merely appear significant behavior transition in "click on keyword to view text information (A12)" to "change keyword and year (A5)" (Z = 4.046).

In terms of difference in behavioral model, learners with low learning performance showed the behavioral model of using directly and simply keyword search to explore related text data. However, the high learning performance group would explore related text data by using systematic inquiry ways combining keyword search and perspective change tool.

4.3.5 Comparison of learners with different learning performance on behavior transition in exploring perspective network diagram

By observing the behavior transition of learners with different learning performance using the "operate perspective network diagram (A9)" function of PCCDT (Table 6), learners with high/low learning performance revealed significant behavior transitions in "period switch (A4)" to "operate perspective network diagram (A9)" (Z = 3.522 for high, Z = 7.524 for low), "operate perspective network diagram (A9)" to "click on keyword to view text information (A12)" (Z = 6.919 for high, Z = 8.290 for low), and "operate perspective network diagram (A9)" to "view

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Table 5. Learners with Different Learning Performance—Behavior Model Difference in Click on Keyword to View Text Information

Perspective Change and Chronological Division Tool (PCCDT)		
	High learning performance (n = 6)	Low learning performance (n = 7)
operate perspective network diagram (A9) → click on keyword to view text information (A12)	6.919	8.290
view keyword (A11) → click on keyword to view text information (A12)	6.341	6.752
click on keyword to view text information (A12) → change keyword and year (A5)		**4.046**
click on keyword to view text information (A12) → search of perspective change tool (B5)	**2.464**	
click on keyword to view text information (A12) → back to keyword page (A13)	**3.820**	
click on keyword to view text information (A12) → keyword search (A1)	**2.945**	

Table 6. Learners with Different Learning Performance—Behavior Model Difference in Operate Perspective Network Diagram

	High learning performance (n = 6)	Low learning performance (n = 7)
Perspective Change and Chronological Division Tool (PCCDT)		
period switch (A4) → operate perspective network diagram (A9)	3.522	7.524
operate perspective network diagram (A9) → click on keyword to view text information (A12)	6.919	8.290
operate perspective network diagram (A9) → view keyword (A11)	2.112	2.877
back to perspective network diagram (A10) → operate perspective network diagram (A9)	**2.846**	
Digital Humanities Research Platform for Mr. Lo Chia-Lun's Writings (DHRP-MLCLW)		
search of perspective change tool (B5) →operate perspective network diagram (A9)	**2.983**	

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keyword (A11)" (Z = 2.112 for high, Z = 2.877 for low). Nevertheless, only learners with high learning performance demonstrated significant behavior transition in "back to perspective network diagram (A10)" to "operate perspective network diagram (A9)" (Z = 2.846) and "search of perspective change tool (B5)" to "operate perspective network diagram (A9)" (Z = 2.983).

The result reveals that learners with high learning performance, in the use of DHRP-MLCLW, were more likely to use the search function of PCCDT and operated a perspective network diagram in the PCCDT to explore related text data. Such a behavioral model suggests that learners with high learning performance, compared with learners with low learning performance, better understood to simultaneously use two tools to explore related text data for supplementing learning.

4.4 Qualitative interview analysis

After the experiment, four research participants were randomly sampled for a semi-structured in-depth interview in order to acquire the user perception of the system operation and the suggestions for system improvement in the future. Most interviewees expressed that DHRP-MLCLW could help them proceed historical investigation through the perspectives that are different from textbooks, be a tool to support historical investigation, and extend effective learning channel for course content. In regard to the function perception, "automatic annotation" and "keyword annotation" functions could help them interpret texts. "Automatic annotation" could assist in reading difficult words; "keyword highlight" could help them rapidly view text content with keywords; the scanned texts of "reading interface" could effectively help them read text for close reading; and, "post-classification of search result" could help organize search results and found context.

Most interviewees, when performing history inquiry-based learning with PCCDT, indicated that the tool provides them with deep experience in inquiry-based learning. Using keyword search through the perspective network diagram of the PCCDT allows learners to discover connections previously not thought of, from various perspectives as well as explore relevant texts with larger coverage of keywords and the related vocabularies to help them understand the history events. In addition to core functions, most interviewees revealed that "external search" could help them explore relevant text data from the Internet. The external search by connecting with external websites, such as other digital humanities platforms, Google, and Wikipedia could help them search more relevant data for learning.

Regarding the improvement of platform tool, most interviewees suggested increasing the archived text quantity or types, reinforcing the explanation of information visualization and the human-computer interaction of reading interface, as well as enhancing the interface intuitiveness of PCCDT's functions.

5. Discussion

The research results show a statistically significant difference in learning performance before and after using DHRP-MLCLW with PCCDT to support an inquiry-based learning for historical investigation, revealing that the digital humanities research platform supported history

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inquiry course has good learning performance. The result echoes several previous studies using digital humanities tools/platforms to support humanities education (Chen et al., 2019; Sit & Guo, 2019; Zhou, 2020), indicating that digital humanities tools/platforms provide benefits in facilitating humanities education. Besides, learners present positive learning satisfaction towards the learning mode with the support of DHRP-MLCLW with PCCDT for history inquiry-based learning, showing great potential of digital humanities research platform supported history inquiry-based learning as the innovative humanities education mode in the future.

Moreover, lag sequential analysis of learners' operation of DHRP-MLCLW with PCCDT appears some explanatory behavior difference. First, learners with high learning performance obviously used "keyword search & double-word search" fewer than learners with low learning performance. The interview results show that some interviewees simply regarded DHRP-MLCLW as the support for the exploration of PCCDT to supplement text data not in the reading perspective change tool. In other words, learners desired the complete inquiry process; in comparison with keyword search in DHRP-MLCLW, more of them would choose the perspective network diagram in PCCDT for the inquiry and use DHRP-MLCLW for supplementing the shortage of text quantity in the tool. After searching keywords and reading text data, learners with high learning performance would return the previous page for continuously exploring other relevant texts. In this case, learners with high learning performance demonstrated significant behavioral transition between behavioral modes of "reading interface → click on article" and "reading interface → click on writing browse article"; learners with low learning performance, on the other hand, would choose to directly re-search new keywords. Such a difference in behavioral mode reveals that learners with high learning performance, in addition to reading text data of keyword search result, would explore text data related to keywords, while learners with low learning performance purely focused on reading text data of keyword search result. Finally, in regard to the mutual behavioral mode of learners using PCCDT and DHRP-MLCLW, learners with high learning performance would use the search function of PCCDT on DHRP-MLCLW for further exploration through the perspective network diagram, when the keyword related data are insufficient. As a result, learners with high learning performance appeared notable behavior transition on "search of perspective change tool → operate perspective network diagram." Apparently, the research findings of this study echo Chen and Wang's study (2020) in mining effective learning behaviors of junior high school's students who used a web-based inquiry science environment to explore buoyancy concepts in a physics course, indicating that the learners with high learning performance have better inquiry learning concepts and abilities than those with low learning performance. This study thus suggests that cultivating students with good inquiry learning concepts and abilities is absolutely needed before proceeding in a history inquiry course with the support of digital humanities research platform.

From above analysis results, DHRP-MLCLW and PCCDT are mutually supported for inquiry-based learning. The perspective network diagram

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and period switch functions in PCCDT allowed learners to inquire historical text in specific periods from distinct aspects and reading relevant historical texts on DHRP-MLCLW. This study confirms that a digital humanities research platform providing both close reading and distant reading functions with connection for users' mutual reference could effectively facilitate students' learning performance in a history inquiry course (Jänicke et al., 2017; Moretti et al., 2016).

6. Conclusions and Future Works

This study aimed to explore the effects of DHRP-MLCLW with PCCDT supported history inquiry-based learning on senior high school students' learning performance, learning satisfaction, and learning behavior transition. The results revealed that DHRP-MLCLW with PCCDT supported history inquiry-based learning could effectively enhance students' learning performance due to the benefits in providing students with good historical investigation environment. Besides, the mean of learners' learning satisfaction is higher than the mean of 6-point scale, showing that learners possessed positive attitudes towards the learning mode. According to learners' feedback on the learning satisfaction questionnaire, most learners agreed that such a learning model could help them find out new clues related to the inquiry problems and precede learning with brand-new thinking methods. Meanwhile, it is also considered that the learning mode, in comparison with traditional teaching from teachers, is novel and interesting. In regard to learners' behavior differences of learners with different learning performance, learners with high learning performance would set a target keyword and then use period switch and perspective network diagram in PCCDT on DHRP-MLCLW for repeatedly exploring relevant data; after matching with text reading, they would return the perspective network diagram, when necessary, to explore new data. It was revealed that the use of PCCDT developed on DHRP-MLCLW could effectively support learners' history perspectives exploration.

The experimental process planned in this study did not contain student discussion, due to the limit of learning time. Mutual discussion with others could assist learners in reflecting the inquiry-based learning process (Pedaste et al., 2015), finding out personal and others' advantages and shortcomings, and re-inspecting and improving personal learning strategies to promote learning performance. For this reason, it is suggested that adding discussion activity in the inquiry-based historical investigation learning with the support of digital humanities research platform should be considered in the future in order to reinforce students' learning performance, learning motivation, and collaborative learning.

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數位人文研究平臺支援探究式學習促進學生的歷史調查成效

Inquiry-based Learning with a Digital Humanities Research Platform's Support to Facilitate Students' Historical Investigation Performance

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摘　要

歷史調查是一種探究式學習，旨在引導學生在歷史文本的閱讀和探索過程中，提高歷史思維能力。本研究利用具觀點變遷與年代劃分之「羅家倫先生文存數位人文研究平臺」輔以高中生進行歷史探究學習，並採用前實驗研究設計，以臺灣臺北市一所高中的13名10年級學生為研究對象，探討此一平臺輔以進行歷史探究學習是否可以顯著促進探究式學習表現，並調查學習滿意度。此外，也採用滯後序列分析探討高學習成效學習者的有效平臺操作行為轉移模式。結果顯示，此一平臺可以有效地提高學習成效，並導致高度正向的學習滿意度。此外，相較於低學習成效學習者，高學習成效學習者在使用此一平臺輔以進行歷史調查探究式學習時的行為模式，更能體現探究式學習的精神。

關鍵字：探究式學習、數位人文與科技、歷史調查、學習成效評估、學習行為分析

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